EVALUATION OF THE EFFECTIVENESS OF COMBINED PHOTOBIOMODULATION AND PIEZOCISION ON THE RATE OF ORTHODONTIC TOOTH MOVEMENT - A RANDOMIZED CONTROL TRIAL

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1. PREAMBLE

A certain demerit of orthodontic treatment is its increased treatment time. This has led to patients interrupting the treatment or declining it together. The average orthodontic treatment lasts 18-24 months and carries with it an increased risk of gingivitis, caries and root resorption[1,2,3].

This led to several studies being conducted to decipher methods to accelerate tooth movements and decrease treatment time.

Several researchers have introduced low-friction self-ligating brackets (SLB) systems with claims to reduce treatment time and provide efficient orthodontic treatment. However recent studies denote that the treatment time is not significantly reduced when SLB were used [4,5].

Corticotomy was introduced by Wilko in 2001 as a surgical method which would reduce treatment time. This method was a combination of corticotomy surgery followed by alveolar bone grafting. Benefits such as decreased root resorption and improved post-orthodontic stability were observed. However, this method proved to be invasive and was not accepted widely due to its aggressive nature [6,7].

In 2009, Dibart introduced a minimally invasive surgical approach termed piezocision wherein micro incisions were placed on the buccal aspect using a piezoelectric knife. Initial studies reported a high degree of patient acceptance and reduced post-surgical discomfort [8,9].

In recent years, low-level laser therapy (LTTT) or photobiomodulation therapy (PBMT) has gained traction as a non-invasive tool which has the potential to accelerate tooth movements.

Photobiomodulation increases the synthesis of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) and increases cellular mitotic activity. It stimulates the proliferation of osteoclasts, osteoblasts, and fibroblasts, thereby affects bone remodelling and accelerating tooth movement. Its sutural bone regeneration activity has been studied in depth by Saito and Shimizu[10]. In addition, an analgesic effect was demonstrated by PBMT.

In this context, the present study aimed at providing further clarity the effectiveness of the low-intensity laser and peizocision on the acceleration of orthodontic tooth movement. A further investigation combining the two techniques was carried out to demonstrate a synergistic effect if any.

2. AIM AND OBJECTIVES

AIM

To evaluate and compare the effectiveness and the biomechanical effects of photobiomodulation and piezocision as a split-mouth clinical trial, and to combine their effects in order to derive a synergetic effect if any.

OBJECTIVES

1. To calculate and compare the rate and effectiveness of canine retraction with the use of conventional fixed orthodontic mechanotherapy in one quadrant vs the use of piezocsion.

2. To calculate and compare the rate and effectiveness of canine retraction with the use of conventional fixed orthodontic mechanotherapy in one quadrant vs the use of photobiomodulation.

3. To calculate and compare the rate and effectiveness of canine retraction with the use of conventional fixed orthodontic mechanotherapy in one quadrant vs the use of Combined photobiomodulation.and Piezocision

3. REVIEW OF LITERATURE

A study conducted by **Kawasaki and Shimizu** (2000) demonstrated the effect of low-level laser irradiation on tooth movements and bone remodelling in rats. This study was conducted using 10g of force on the molar teeth of rats which were then irradiated with Ga-Al-As diode laser. The amount of tooth movement was calculated after a period of 12 days. In addition, the newly formed bone was stained with Calcein for the purpose of quantitative analysis. It was observed that the experimental group with irradiated molar teeth showed 1.3 times greater tooth movement compared to the control group.

Cruz et al (2004) conducted a study which investigated the effect of low intensity laser therapy on the velocity of orthodontic tooth movement. The 11 subjects were subjected to a diode laser emitting light with a wavelength of 780nm on one half of the arch. Laser therapy was carried on 4 days of every month, for 10 seconds at 20mW and 5J/cm^2. Both sides of the arches were subjected to mechanical canine retraction. The progress of both sides was evaluated and compared. The results showed an accelerated effect on canine retraction of the irradiated side. This suggests that low intensity laser therapy may have a beneficial effect on reducing orthodontic treatment time.

Limpanichkul et al (2006) investigated the effect of low-level laser therapy (LLLT) on orthodontic tooth movement. The split-mouth study was carried on 12 patients who were irradiated on one side with GaAlAs laser, with a surface energy density of 25J/cm. The study used tension coils for retraction of the maxillary canines into first premolar space. The experimental side was irradiated buccally, palatally and distally on the mucosa. The tooth movement was evaluated using casts which were measured using a stereomicroscope. It was observed that no significant difference was present between the experimental side and the control.

A clinical investigation was carried out by **Doshhi-Mehta and Bhad-Patil** (2012) to determine the effectiveness of low-intensity laser therapy in reducing the treatment time of orthodontic therapy. This split-mouth study was carried out using an Aluminum-Gallium-Arsenide diode with a wavelength of 810nm. Only cases requiring first premolars extraction were selected for the study and canine retraction was carried

out using NiTi closed coil springs. The laser therapy was carried out on the 1st, 3rd, 7th and 14th day of the first month, subsequently, it was carried out every 15th day. A 30% increase in the rate of tooth movement was observed on the irradiated side. Thus, the study suggests a significant effect in the reduction of treatment time when using low-intensity laser therapy.

Chung How Kau et al (2013) conducted a clinical trial at multiple centres consisting of 90 patients. The little's irregularity index was used to effectively measure the rate of tooth movement. The surfaces of the cheeks of the test subjects were irradiated with 850nm wavelength and power density of 60Mw/cm2 for 20-30 minutes per day or 60 minutes per week to achieve total energy densities of 72, 108 and 216J/cm2. A clinically significant change was detected with respect to the tooth movement in the subjects who were subjects to photobiomodulation. Rates of tooth movement in the patients subjected to photobiomodulation were seen to be 1.12mm/week compared to 0.49mm in the control group.

Nimeri et al (2013) reviewed 74 articles related to orthodontic tooth movement.It was observed that cytokines, parathyroid hormone (PTH), vitamin D as well as RANK/RANKL/OPG showed an increase in tooth movement whereas relaxin only increased the tooth mobility.the greatest acceleration in tooth movement was observed in the surgical approach however this method was rarely used due to its invasiveness. Photobiomodulation on the other hand was observed to stimulate the regeneration of bone and the proliferation of osteoblasts, osteoclasts and fibroblasts, in turn accelerating tooth movements.

Heravi et al (2014) studied the effectiveness of low level laser therapy on tooth movements. 20 patients requiring first premolar extractions were selected for the study. A split-mouth study design was employed for this trial, with the irradiated side of the arch being irradiated with a Gallium-Aluminum-Arsenide diode with a wavelength of 810nmthe laser therapy protocol was carried out on day 3, 7, 11 and 15. The results showed that there was no significant difference in the rate of tooth movement in the irradiated and control side.

Kansal et al (2014) conducted a study to determine the effect of low intensity laser therapy (LILT) on the rate of tooth movement. 10 subjects were selected for this split-mouth study. A force of 150 grams was applied for the purpose of canine retraction. The experimental side in addition to the mechanical force, received irradiation from a Gallium-Arsenide laser with a wavelength of 904nm.cahnges in the periodotium were monitored radiographically. The results revealed no significant difference between the irradiated group and the control. No pathologic findings were present in the experimental group.

Shaughnessy et al (2016) conducted a study to determine the effect of photobiomodulation on orthodontic treatment time. 19 patients with either Class I or Class II malocclusion with Littles's irregularity index of ≥3mm were selected for the study. A non-extraction treatment protocol was used for the study. Infrared therapy of 850nm wavelength with energy density of 9.5J/cm was used on the buccal aspect of the gums in the experimental group. The SPEED self-ligating bracket system was used in the control group whereas conventionally ligated Ormco Mini-twin brackets were used in the experimental group. Initial alignment was carried out on 0.014" NiTi with identical arch wire changes. The group receiving photobiomodulation had an accelerated rate of alignment with a change in the Little's irregularity index of 1.27mm/week, whereas the control group had a change of Little's irregularity index of 0.44mm/week. The alignment in the experimental group took an average of 48 days whereas the control group took an average of 104 days. A 2.9 fold increase in rate of tooth movement in patients subjected to photobiomodulation.

A study was conducted by **Abbas** et al (2016) to determine the effectiveness of corticotomy facilitated orthodontics and peizocision in accelerating tooth movements. This split mouth study subjected the patients to corticotomy on one side of the arch and the other group subjected the patients to peizocision on one side of the arch. It was revealed that the rate of canine retraction into the extraction space was higher on the side where corticotomy was carried out. Patients with peizocision had an accelerated rate of tooth movement but its rates were lower when compared to the corticotomy side.

Qamruddin et al (2017) conducted a study to determine the effect of low level laser (LLLT) irradiation on the rate of tooth movement in a self-ligating bracket system. 22 patients with Class 2 division 1 malocclusion were selected for this split mouth clinical study. After initial alignment and levelling, a 150 grams retractive force was applied on the canine. A Gallium-Aluminium-Arsenide diode laser was used at 5 points on the canine root in a continuous manner. The energy density was 7.5J/cm^2/point. The laser therapy was repeated after 3 weeks for 2 visits on the irradiated side. Retraction was carried out using 6mm closed coil NiTi springs. Evaluation of rate of canine retractions were made based on casts. It was observed that the irradiated group had significantly higher rate of tooth movement compared to the control. This suggests that LLLT may accelerate tooth movement.

Abdelhameed and Refai (2018) conducted a study to determine the effect of low-energy laser therapy, micro-perforation and a combination of low-energy laser therapy (LLLT) and micro-perforation (MOP) on the effect of tooth movement. This split-mouth study was carried out whilst measuring the distance from the canine cusp tip to the mesiobuccal cusp tip of the 1^{st} molar. A 1.3-fold increase in the rate of tooth movement was observed on the LLLT side compared to standard canine retraction. Similarly1.6-fold increase in tooth movement was observed on the MOP side compared to standard canine retraction. A synergistic effect with a 1.8-fold increase was observed when the two methods were combined.

Alfawal et al (2018) conducted a study evaluating the acceleration of canine retraction in peizocision and laser-assisted flapless corticotomy. Patients requiring first premolars extraction were selected for the split-mouth study. A significant increase in the rate of canine retraction was observed in the experimental groups that underwent the laser-assisted flapless corticotomy and peizocision. It was found to be 2-fold in the first month and 1.5-fold in the second month in both experimental groups. The study demonstrated the use of peizocision and laser-assisted corticotomy on rate of orthodontic tooth movement.

A study was conducted by **Cifter** et al (2019) to analyse the efficacy of alveolar decortication (AD) and low-level laser therapy (LLLT) on orthodontic tooth movement in rats. In addition, the osteoclast counts and RANKL-OPG levels were evaluated. The albino rats were evaluated at 7 and 14-day intervals. The AD group showed the highest

rate of tooth movements. The LLLT group showed a higher rate of tooth movement compared to the control group. The LLLT group and the AD group showed higher counts for osteoclast levels. This study demonstrates the stimulating effect of LLLT and AD on bone remodelling.

Isola et al (2019) conducted a study to evaluate the effect of low-level laser therapy (LLLT) on tooth movement. The study was conducted comparing the rate of canine retraction in 41 patients requiring extraction of the first premolars. Canine retraction was carried out using NiTi coil springs with a force of 50N. The study design was a split mouth study, with one side being irradiated with a diode laser of 810nm wavelength. A continuous wave of 66.7J/cm^2 was used at 3 sites on the buccal, palatal and distal aspect. Th control side of the arch was subjected to a mechanical traction. When compared to the control, the experimental group showed an accelerated tooth movement, with a mean of 84 days to complete the canine retraction, whereas the control needed an average of 97 days. In addition, a reduction in pain was observed by the test subjects on the irradiated side.

A study conducted by **Mistry** et al (2020) demonstrated the effectiveness of low-level laser therapy on maxillary canine distalisation. 22 patients in the age group of 13-25 years requiring bilateral first premolar extractions were selected for the study. Canine traction was carried out using NiTi closed coil springs with 150grams of force. On the experimental side the laser therapy was applied at various points around the canine root on the palatal and buccal aspects on day 0, day 28 and day 56. A 0.25mm difference was noticed between the two groups, which proved to be clinically insignificant. Therefore, it was observed that low level laser therapy did not accelerate tooth movement significantly.

Giudice et al (2020) conducted a study to evaluate the effect of photobiomodulation during decrowding in the mandibular arch in young patients. This clinical trial employed a total of 89 subjects between the ages of 13 to 30 years. The subjects had permanent dentition with a Class I occlusal relationship with mild anterior mandibular crowding. All patients received a non-extraction treatment plan. The patients in the experimental group received photobiomodulation therapy every 14 days with 72J/cm^2 fluency. The alignment was evaluated clinically and compared. The results demonstrated a decrease in treatment time in the group receiving low level laser

therapy, with an average of 203 days in the experimental group and an average of 260 days in the control group. Hence, photobiomodulation can be used to enhance the efficiency of orthodontic mechanotherapy.

A study was conducted by **Impellizzeri** et al (2020) to evaluate the effectiveness of photobiomodulation on the rate of tooth movement. This study was based on initial reports of photobiomodulation having regenerative and biostimulatory potential. This study was conducted on 6 patients who underwent extraction treatment protocols. The canines were retracted using lacebacks in this split-mouth study. Irradiation in the experimental side was carried out using Aluminum-Gallium-Arsenide double diode with wavelengths of 650nm and 910nm simultaneously emitted. The laser therapy was carried out for four cycles on day 0, day 3, day 7 and day 14. An accelerated rate of tooth movement of 1.98mm/month was observed on the irradiated side while a rate of 1.35mm/month was observed on the control side. Hence, photobiomodulation has the potential to effectively accelerate tooth movement.

A study was conducted by **Pereira** et al (2020) to determine the rate of orthodontic tooth movement in patients treated with low level laser therapy. A sample consisting of 11 subjects with Class I malocclusion requiring extractions of the first premolars was selected. This split-mouth study made use of the Gallium-Aluminium-Arsenide diode laser with a wavelength of 780nm. It was observed that no significant difference was found between the irradiated and non-irradiated sides, with both sides demonstrating similar rates of tooth movement. In addition, radiographic evidence showed no resorption of the bone and tooth root.

Qamruddin et al (2021) evaluated the photobiostimulatory effects of low level laser therapy (LLLT) on orthodontic tooth movement in a MBT bracket system. 20 patients with Class II division 1 malocclusion were selected for the study. Alignment and levelling were carried out and canine retraction was continued on 19x 25 stainless steel archwire with NiTi coil springs. This study was a split mouth study, wherein only one side was irradiated with Gallium-Aluminium-Arsenide diode at 10 points. The laser diode had a wavelength of 940nm and was used in a continuous manner. The irradiated tissues were irradiated every 3 weeks for a period of 9 weeks. Casts were recorded to evaluate the rate of tooth movement. Results showed an accelerated tooth movement in the irradiated region, suggestive of the effect of photobiostimulation of LLLT.

A randomised control study conducted by **Perignon** et al (2021) evaluated the effect of low-level laser therapy (LLLT) on orthodontic tooth movement using Class II intermaxillary elastics. Forty-two subjects were included in this split-mouth study. Segmental mechanics were employed in this study to prevent the experimental side from influencing the control side. Class II elastics of 41/2 Oz and 5/6" size were used to retract the maxillary canine. A low energy diode of 970nm wavelength was used on the experimental side and the distance between the maxillary canine tip and mandibular canine tip was measured periodically. The total dosage on the irradiated side was 21.6J. Results of the study revealed that there was a significant impact on the rate of tooth movement when LLLT was used.

Zheng and Kai (2021) conducted a study to evaluate the effect of low-level laser therapy (LLLT) on orthodontic tooth movement. This split-mouth study consisted of 12 patients that underwent first premolar extractions. The diode laser had a wavelength of 810nm and was applied after 0,7, 14 and 21 days after placing active forces for canine retraction. in addition, the IL-B, RANKL and OPG were evalusted. The study was carried for a period of 28 days and higher tooth movements were recorded in the experimental side. A reduction in OPG levels and an increase in RANKL and IL-B levels was observed in the experimental side. This suggests that LLLT has a beneficial effect on the orthodontic tooth movements.

A study conducted by **Al-Shafi** et al (2021) demonstrated the effect of light emitting diode mediated photobiomodulation on the closure of extraction spaces using a split-mouth study design protocol.20 participants between the age group of 11-20 years were selected for the trial. Canine retraction was carried out on 0.020" stainless steel archwire using NiTi coil springs of 150 grams of force. One side of the arch received photobiomodulation therapy of 850nm wavelength, 60mW/cm^2 power for 5 minutes a day. It was observed that no significant differences were present in the experimental and control side suggesting that photobiomodulation has no significant role in reducing orthodontic treatment time.

A study was conducted by **Chauhan** et al (2022) to demonstrate the effect of lasers on orthodontic tooth movement. This split-mouth study was conducted using Er-YAG laser on the irradiated side. Subjects requiring first premolar extraction were selected. Initial alignment and levelling were carried out on a 0.018" Roth system. A

16x22 stainless steel wire was placed and subsequently, the canine distalisation was carried out using 0.9 NiTi coil springs with a force of 150 grams. A significant increase in the rate of canine retraction was observed on the irradiated side.

A study by **Giudice** et al (2022) evaluated the effect of low intensity laser therapy on the rate of orthodontic tooth movement. The study was conducted using gallium-aluminium-arsenide (GaAlAs) diodes. The clinical trial was carried out on 18 selected patients who were subjected to mechanical traction on the canine using a closed coil NiTi spring with a force of 40 grams. The diode laser has a wavelength of 780nm, output power of 20mW with a dose of $5J/cm^2$. Tooth movement was recorded using study casts. The control and experimental sides were compared. it was observed that the side receiving the low intensity laser therapy had an accelerated tooth movement. A reduction in pain experienced by the subjects was also observed.

Guray et al (2022) conducted a study to evaluate the effect of photobiomodulation therapy on the rate of orthodontic tooth movement. The study was conducted with 30 patients requiring first premolar extraction. The rate of canine retraction was evaluated using Paul Gjessing (PG) springs in the control and experimental groups. in addition, the experimental group received photobiomodulation therapy of 850nm wavelength, with an energy density of $63Mw/cm^2$. Study models were used to evaluate the rate of tooth movement. A canine distalisation rate of 1.36mm/ 21 days was observed in the experimental group, whereas a rate of 1.02mm/21 days was observed in the control group. Thus, the photobiomodulation therapy has the potential to increase rate of tooth movement by 33%.

4. MATERIALS AND METHODOLOGY

This randomised clinical trial was carried out on patients reporting to the Department of Orthodontics, Indira Gandhi Institute of Dental Sciences (IGIDS). Patients were enrolled in the study only after obtaining written informed consent. All doubts of the patients regarding the study were clarified.

Inclusion Criteria

- Patients of age group 18-25 years
- Patients with Angle's Class I/ Class II div 1 malocclusion with anterior crowding (greater than 5mm) or bimaxillary protrusion requiring extraction of premolars
- Individuals with healthy periodontium.
- Individuals with a full set of permanent dentitions up to the second molar.

Exclusion Criteria

- Patients who did not provide oral and written consent to participation
- Patients with very poor oral hygiene, active periodontal diseases, and smoking habit
- Patients with systemic illness, neuromuscular disease or debilitating diseases
- Patients with a previous history of orthodontic treatment or surgical treatment.
- Individuals with a history of dental and facial trauma.
- Individuals with mouth-breathing or tongue-thrusting habits
- Patients in the active growth phase
- Individuals with odontogenic pathologies, transpositions, and gross decay.
- Individuals with congenital anomalies and facial asymmetry.
- Patients with gross skeletal and dentofacial deformities which require orthognathic surgery

Sampling procedure

Out of 60 patients reported to the Department of Orthodontics with a chief complaint of irregularly aligned front teeth, a total of 24 patients were selected for this study. The participant selection was based on the inclusion and exclusion criteria as described above and was randomly distributed into 3 groups with 8 patients in each group.

Study Groups

This randomised clinical trial has a split-mouth study design. Three study groups were formed based on the interventional procedures used.

Group 1: Individuals subjected to conventional fixed mechanotherapy in one quadrant and the use of peizocision in the opposite quadrant.

Group 2: Individuals subjected to conventional fixed mechanotherapy in one quadrant and the use of photobiomodulation in the opposite quadrant.

Group 3: Individuals subjected to conventional fixed mechanotherapy in one quadrant and the combined use of peizocision and photobiomodulation in the opposite quadrant.

Randomization:

Randomization was done using computer-based sequence generation using an online platform (randomizer.org). 24 envelopes numbered from 1 to 24 and were marked with any of the three procedures. The envelopes were made by the support staff of the Department of Orthodontics, IGIDS for concealment. Participant enrollment was completed after the distribution of all the sealed envelopes.

Procedure of blinding

The participants were blinded regarding the procedure to be done; however, the researcher was not blinded as the procedures were carried out by the researcher herself. After the completion of the study, the assessment of the rate of tooth movement was done by a separate qualified assessor.

Interventional procedures

The fixed appliance was bonded and En -mass retraction was carried out after 20 weeks by varying procedures as per the groups.

Peizocision

The surgical procedure was carried out on local anaesthesia. Two vertical interproximal incisions (below the interdental papilla) were given on the mesiobuccal and distobuccal aspects of maxillary canines using a no.15 blade. The vertical interproximal incisions of 10mm length and 3mm depth were performed 5mm apical to the mesial and distal interdental papilla of the maxillary canine. A peizocision knife was used to perform the cortical alveolar incisions. Archwires were ligated and the patient was recalled after 3 weeks.

Figure 1: Piezocision technique

Photobiomodulation

A total of 10 irradiations, 5 on the buccal aspect and 5 on the palatal aspect, were performed.

2 irradiation doses were given on the mesial and distal aspects of the cervical third of the root.2 irradiation doses were given on the mesial and distal aspects of the apical third of the root.1 irradiation dose was given on the middle third of the canine, lateral incisor and central incisor of the experimental side and an irradiation dose was given between the contact points of the maxillary canine and 2nd premolar.

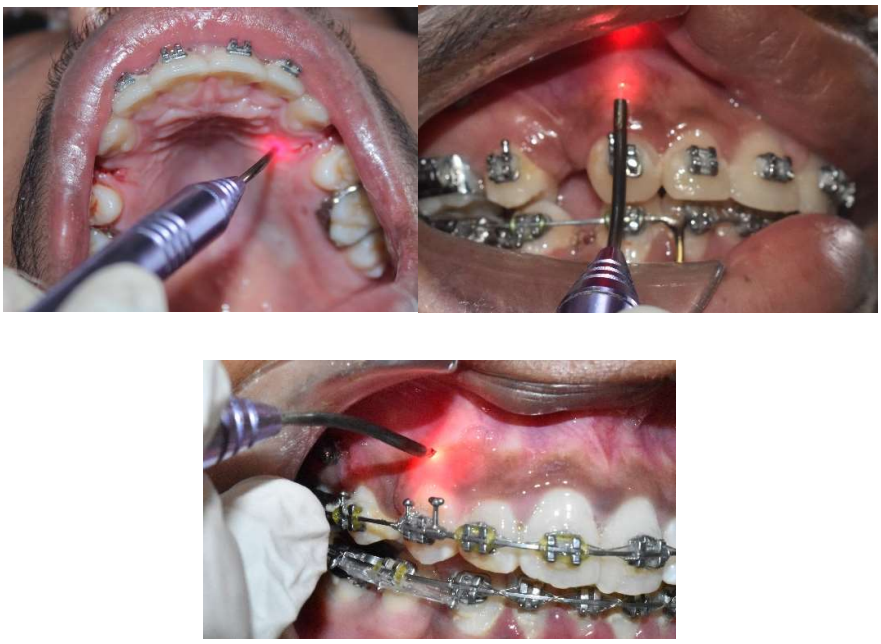


Figure 2: Photobiomodulation technique

The total energy was 10J in the period between the 3 weeks (21, 42, 63). A 19x25 stainless steel archwire was ligated and the model analysis was done on the 84th day to evaluate the rate of tooth movement.

Combined Photobiomodulation and Piezocision

Low Level laser therapy and Pizocision technique was combined in the group III patients. A total of 10 irradiations, 5 on the buccal aspect and 5 on the palatal aspect, were performed immediately after the cortical alveolar incisions were given. A 19x25 stainless steel archwire was ligated and the model analysis was done on the 84th day to evaluate the rate of tooth movement.

Figure 3: The combination of the piezocision and photobiomodulation techniques

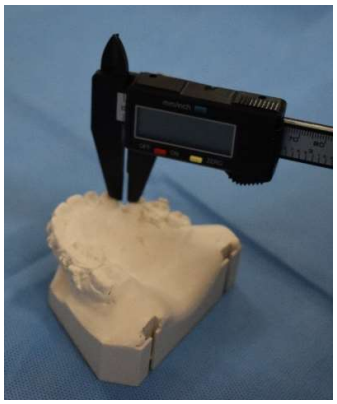


Figure 4: Model analysis carried out using a vernier calliper

Statistical Analysis:

Descriptive statistics of quantitative variables were analysed by using mean and standard deviation.

Descriptive statistics of qualitative variables were summarized by using counts/percentages.

Each of the parameters under the different study groups was analysed by using ANOVA.

If ANOVA was significant, post-Hoc test was conducted.

Carl- Pearson correlation was used to find the correlation between the different parameters in the study.

$P<0.05$ was considered statistically significant.

SPSS was used to analyse the data collected.

S. No	Name of the dependent/independent variables	Scale of measurement (Quantitative / qualitative)	Descriptive / Inferential Statistics to be used
1.	Dependent – Rate of space closure	Quantitative	ANOVA, Post hoc Tukey
2.	Dependent- Loss of Anchorage	Quantitative	ANOVA, Post hoc Tukey

5. RESULTS

This randomised clinical trial was carried out on patients reporting to the Department of Orthodontics, Indira Gandhi Institute of Dental Sciences (IGIDS) after obtaining informed consent. This study was conducted to assess the effect of piezocision, photobiomodulation and a combined effect of the two techniques on the rate of tooth movement using a split-mouth study design.

Three study groups were formed based on the interventional procedures used.

Group 1: Individuals subjected to conventional fixed mechanotherapy in one quadrant and the use of piezocision in the opposite quadrant.

Group 2: Individuals subjected to conventional fixed mechanotherapy in one quadrant and the use of photobiomodulation in the opposite quadrant.

Group 3: Individuals subjected to conventional fixed mechanotherapy in one quadrant and the combined use of piezocision and photobiomodulation in the opposite quadrant.

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp. The results on continuous measurement are presented as mean & standard deviation (SD) and categorically as frequency & percentage. Inferential statistics such as ANOVA was applied to compare the three groups and post-hoc Tukey was applied to check the difference between any two groups which were found significant in ANOVA. An Independent t-test was used to compare the two groups. A p-value less than 0.05 was considered to be statistically significant.

Table 1: Tabulation representation of the rate of tooth movement in patients subjected to piezocision and conventional canine retraction technique

SAMPLE	VARIABLE	T1	T2	T3
N1	Control side	0.48	0.54	0.61
	Experimental side	0.66	0.58	0.63
N2	Control side	0.66	0.61	0.68
	Experimental side	0.82	0.69	0.72
N3	Control side	0.58	0.57	0.61
	Experimental side	0.82	0.61	0.64
N4	Control side	0.46	0.53	0.57
	Experimental side	0.82	0.57	0.59
N5	Control side	0.93	0.83	0.75
	Experimental side	0.82	0.83	0.77
N6	Control side	0.47	0.59	0.57
	Experimental side	0.82	0.65	0.61
N7	Control side	0.7	0.8	0.67
	Experimental side	0.82	0.67	0.69
N8	Control side	0.62	0.73	0.75
	Experimental side	0.82	0.79	0.72

Table 2: Tabulation representation of the rate of tooth movement in patients subjected to photobiomodulation and conventional canine retraction technique

SAMPLE	VARIABLE	T1	T2	T3
N1	Control side	0.45	0.53	0.61
	Experimental side	0.5	0.59	0.63
N2	Control side	0.6	0.59	0.63
	Experimental side	0.68	0.66	0.71
N3	Control side	0.58	0.57	0.61
	Experimental side	0.61	0.61	0.64
N4	Control side	0.44	0.5	0.61
	Experimental side	0.53	0.55	0.59
N5	Control side	0.83	0.67	0.61
	Experimental side	0.97	0.77	0.77
N6	Control side	0.47	0.53	0.61
	Experimental side	0.57	0.59	0.63
N7	Control side	0.7	0.8	0.67
	Experimental side	0.79	0.97	0.69
N8	Control side	0.62	0.73	0.61
	Experimental side	0.73	0.79	0.77

Table 3: Tabulation representation of rate of tooth movement in patients subjected to the combination of piezocision and photobiomodulation technique and conventional canine retraction technique

SAMPLE	VARIABLE	T1	T2	T3
N1	Control side	0.45	0.53	0.61
	Experimental side	0.5	0.59	0.63
N2	Control side	0.6	0.59	0.63
	Experimental side	0.68	0.66	0.71
N3	Control side	0.58	0.57	0.61
	Experimental side	0.61	0.61	0.64
N4	Control side	0.44	0.5	0.61
	Experimental side	0.53	0.55	0.59
N5	Control side	0.83	0.67	0.61
	Experimental side	0.97	0.77	0.77
N6	Control side	0.47	0.53	0.61
	Experimental side	0.57	0.59	0.63
N7	Control side	0.7	0.8	0.67
	Experimental side	0.79	0.97	0.69
N8	Control side	0.62	0.73	0.61
	Experimental side	0.73	0.79	0.77

The descriptive statistical analysis for Group 1 has been documented in Table 4 and comparisons between the conventional canine retraction technique and piezocision technique has been documented in Table 5. The mean values in Group 1 have been graphically represented in Graph 1.

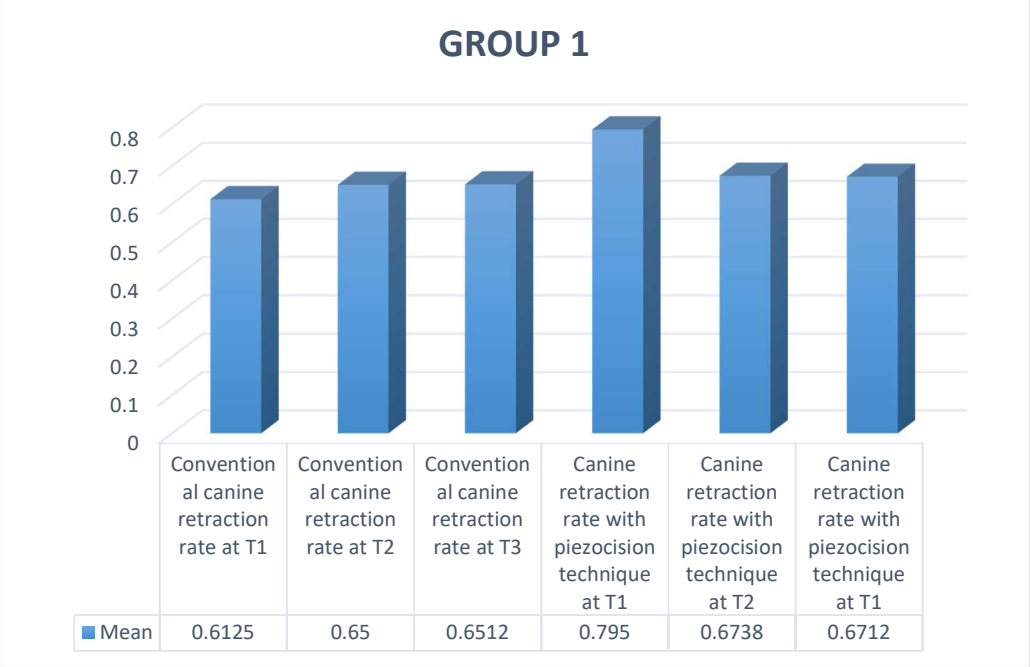
Table 4: Descriptive statistics of Group 1 consisting of patients subjected to piezocision and conventional canine retraction technique

	N	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Std. Error
Conventional canine retraction rate at T1	8	.6125	.15719	1.176	.752
Conventional canine retraction rate at T2	8	.6500	.11916	.661	.752
Conventional canine retraction rate at T3	8	.6512	.07298	.364	.752
Canine retraction rate with piezocision technique at T1	8	.7950	.13191	.376	.752
Canine retraction rate with piezocision technique at T2	8	.6738	.09441	.719	.752
Canine retraction rate with piezocision technique at T3	8	.6712	.06312	.253	.752
Valid N (listwise)	8				

Table 5: Comparison of conventional canine retraction technique and piezocision technique at T1, T2 and T3

Group Statistics					
	Group 1	N	Mean	Std. Deviation	P value
T1	Conventional canine retraction technique	8	.6125	.15719	**.739**
	Piezocision technique	8	.7950	.13191	
T2	Conventional canine retraction technique	8	.65	.119	**.252**
	Piezocision technique	8	.67	.094	
T3	Conventional canine retraction technique	8	.65	.073	**.617**
	Piezocision technique	8	.67	.063	

Graph 1: Graph depicting the mean rate of canine retraction in Group 1 patients



The descriptive statistical analysis for Group 2 has been documented in Table 6 and comparisons between the conventional canine retraction technique and photobiomodulation technique has been documented in Table 7. The mean values in Group 2 have been graphically represented in Graph 2.

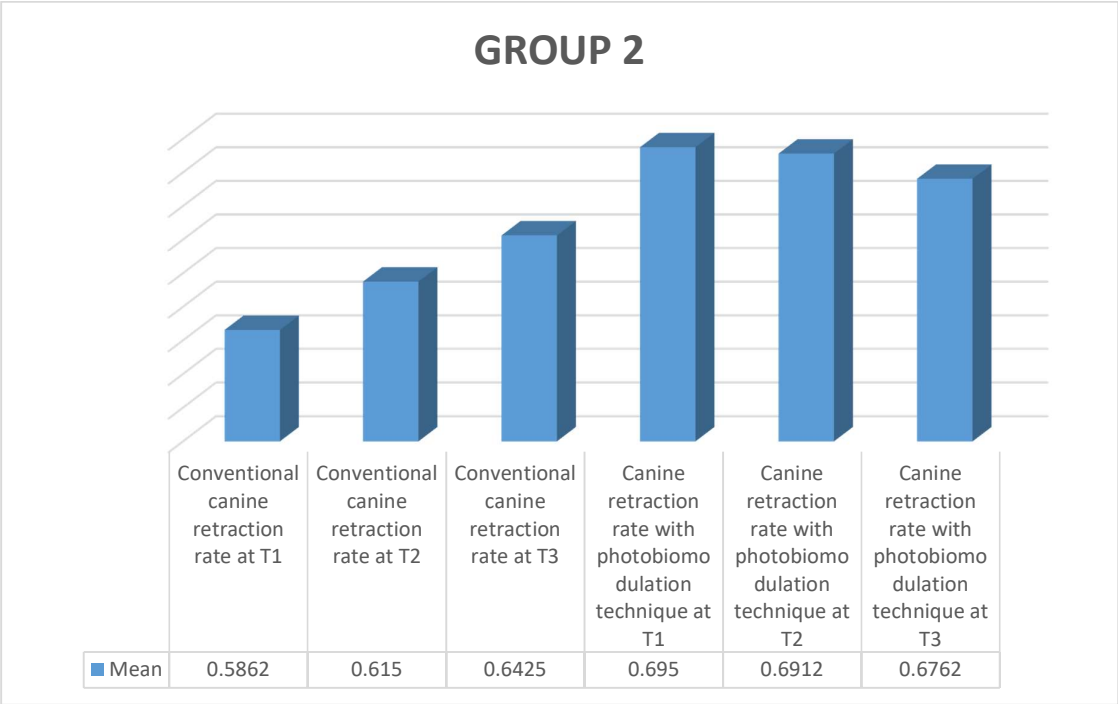
Table 6: Descriptive statistics of Group 2 consisting of patients subjected to photobiomodulation and conventional canine retraction technique

	N	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Std. Error
Conventional canine retraction rate at T1	8	.5862	.13479	.682	.752
Conventional canine retraction rate at T2	8	.6150	.10744	.793	.752
Conventional canine retraction rate at T3	8	.6425	.06840	.655	.752
Canine retraction rate with photobiomodulation technique at T1	8	.6950	.15856	.415	.752
Canine retraction rate with photobiomodulation technique at T2	8	.6912	.14227	1.167	.752
Canine retraction rate with photobiomodulation technique at T3	8	.6762	.06989	.340	.752
Valid N (listwise)	8				

Table 7: Comparison of conventional canine retraction technique and photobiomodulation technique at T1, T2 and T3

Group Statistics					
	Group 2	N	Mean	Std. Deviation	P value
T1	Conventional canine retraction technique	8	.59	.135	**.576**
	Photobiomodulation technique	8	.70	.159	
T2	Conventional canine retraction technique	8	.62	.107	**.434**
	Photobiomodulation technique	8	.69	.142	
T3	Conventional canine retraction technique	8	.64	.068	**.849**
	Photobiomodulation technique	8	.68	.070	

Graph 2: Graph depicting the mean rate of canine retraction in group 2 patients



The descriptive statistical analysis for Group 3 has been documented in Table 8 and comparisons between the conventional canine retraction technique and the combination of photobiomodulation and piezocision techniques has been documented in Table 9. The mean values in Group 3 have been graphically represented in Graph3.

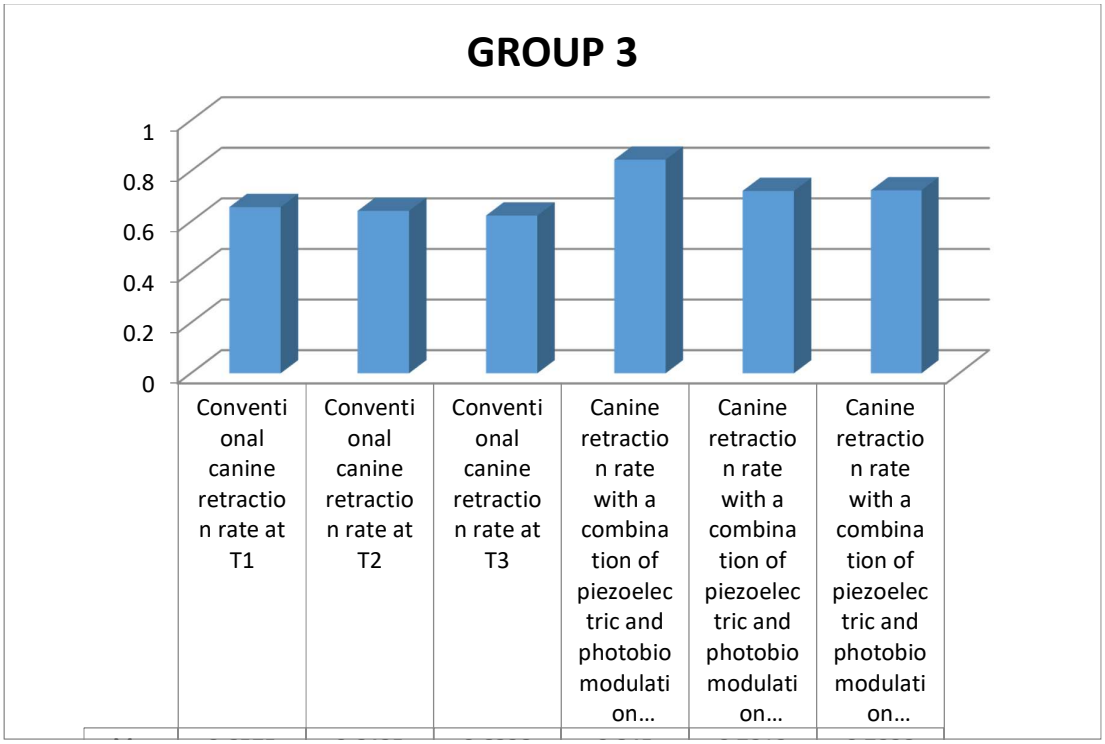
Table 8: Descriptive statistics of Group 3 consisting of patients subjected to combination of piezoelectric and photobiomodulation techniques and conventional canine retraction technique

Descriptive Statistics					
	N	**Mean**	**Std. Deviation**	**Skewness**	
	Statistic	Statistic	Statistic	Statistic	Std. Error
Conventional canine retraction rate at T1	8	.6575	.15989	.495	.752
Conventional canine retraction rate at T2	8	.6425	.10951	.361	.752
Conventional canine retraction rate at T3	8	.6238	.10084	-.245	.752
Canine retraction rate with a combination of piezoelectric and photobiomodulation techniques at T1	8	.8450	.13191	.376	.752
Canine retraction rate with a combination of piezoelectric and photobiomodulation techniques at T2	8	.7212	.09775	.591	.752
Canine retraction rate with a combination of piezoelectric and photobiomodulation techniques at T3	8	.7238	.06567	.213	.752
Valid N (listwise)	8				

Table 9: Comparison of conventional canine retraction technique and combination of piezoelectric and photobiomodulation techniques at T1, T2 and T3

Group Statistics					
	Group 3	**N**	**Mean**	**Std. Deviation**	**P value**
T1	Conventional canine retraction technique	8	.66	.160	**.355**
	Combination of piezoelectric and photobiomodulation technique	8	.84	.132	
T2	Conventional canine retraction technique	8	.64	.110	**.787**
	Combination of piezoelectric and photobiomodulation technique	8	.72	.098	
T3	Conventional canine retraction technique	8	.62	.101	**.368**
	Combination of piezoelectric and photobiomodulation technique	8	.72	.066	

Graph 3: Graph depicting the mean rate of canine retraction in Group 3 patients


GROUP 3
1
0.8
0.6
0.4
0.2
0
Conventional canine retraction rate at T1
Conventional canine retraction rate at T2
Conventional canine retraction rate at T3
Canine retraction rate with a combination of piezoelectric and photobiomodulation…
Canine retraction rate with a combination of piezoelectric and photobiomodulation…
Canine retraction rate with a combination of piezoelectric and photobiomodulation…

6. DISCUSSION

Orthodontists have constantly been seeking new methods to accelerate orthodontic tooth movements, thereby reducing overall treatment time and enhancing treatment outcomes.

Surgical methods such as corticotomy were met with resistance due to their invasive nature, need for flap elevations and post-surgical discomfort. In addition, corticotomy may lead to the formation of dehiscence and increased tooth mobility. A novel approach to enhance tooth movement was a minimally-invasive surgical procedure termed as piezocision. Minor incisions were placed in the cortical alveolar bone and gingiva with a piezo surgical knife. Several benefits such as reduced patient discomfort were noted, which led to its popularity and widespread acceptance.

In recent years, laser therapy in dentistry has gained traction as a non-invasive procedure to enhance orthodontic tooth movement. Several studies have suggested that low-level laser therapy decreases pain and improves patient comfort.

The present study was conducted to assess the influence of piezocision, low-level laser therapy and the combined effect of the two, on the rate of tooth movement. The study had a split-mouth design and conventional canine retraction mechanics were applied in one quadrant whereas the opposite quadrant was subjected to the experimental technique. This was done so as to reduce inter-individual variability in the rate of tooth movement.

Three groups were formed based on the interventional procedure with each group consisting of a sample size of 8. The patients were randomly assigned to the group using an online platform. The rate of tooth movement was analyzed using model casts. The rate of tooth movement was evaluated at three time periods, T1, T2 and T3.

In Group 1 consisting of individuals subjected to conventional fixed mechanotherapy in one quadrant and the use of peizocision in the opposite quadrant, it was observed that an increased overall mean rate of tooth movement was noted at T1 in the quadrant subjected to piezocision. A 0.18 increase in the mean rate was seen at T1 in the experimental side, whereas lowest overall mean rate was noted on the control side. Similar rates of tooth movement were noted on the control side and the

experimental side at T2 and T3. However, no statistically significant difference was noted in the quadrant subjected to piezocision and the control side at T1, T2 and T3. Yi et al, in a systematic review published in 2017, reported that piezocision enhanced tooth movement in the short term, however, the evidence was weak. The increased rate of tooth movement may be due to the effect of the regional acceleratory phenomenon which causes transient bone demineralization and enhanced bone metabolism. A clinical study by Patterson et al noted the increased risk of root resorption associated with the piezocision technique. In addition, iatrogenic trauma to the roots during placement of the surgical cuts was documented in several patients

It was found in another systematic review conducted by Hourara in 2019 that there was deficient evidence to support the hypothesis that piezocision would enhance the rate of tooth movement.

The present study had similar findings to a study conducted by Tuncer et al in 2019 wherein no significant results were noted between the piezocision-assisted and conventional canine retraction methods. A recent split-mouth study conducted by Hawkins et al in 2022 demonstrated no statistically significant results when comparing the orthodontic tooth movement on the piezocision and control side, furthermore patients experienced the pain associated with the procedure.

The findings of the study indicate that piezocision has an immediate effect on the rate of tooth movement, however, this effect does not translate at T2 and T3. Moreover, this procedure may be uncomfortable and painful for the patient, so a more acceptable procedure is needed.

In Group 2, consisting of individuals subjected to conventional fixed mechanotherapy in one quadrant and the use of photobiomodulation in the opposite quadrant, it was observed that higher mean values of rate of tooth movement were noted in the quadrant subjected to low-level laser therapy. A 0.69 rate of tooth movement was observed on the experimental side at T1 and at T2. This was substantially higher when compared to the control but was found to be statistically insignificant. The rate of tooth movement decreased at T3 to 0.67. This was similar to the results demonstrated by Heravi, Morai and Ahrari in 2014, wherein the rate of tooth movement was greater in the first month and declined in the second month.

Similar results were noted in a study conducted by Mistry in 2020, wherein a similar split-mouth study design was employed. A higher rate of tooth movement was seen in the low-level laser therapy group however the differences were found to be not statistically significant.

Another study conducted by Limpanichkul et al in 2006 which employed a GaAlAs laser at 25J/cm^2 showed no statistically significant differences in photobiomodulation-assisted and the conventional technique of canine retraction.

Cruz et al conducted a study with 5J/cm^2 applied at 10 points and demonstrated a bio-stimulatory effect on the alveolar bone. A total of 10J was used in the present study, which may explain why there were no significant differences between the control and experimental groups.

Owing to the non-invasive nature of the procedure, the low-level laser therapy shows a great deal of promise, however, further research may be needed to decipher the precise dosage and wavelength required for optimal rate of orthodontic tooth movement.

In Group 3 consisting of individuals subjected to conventional fixed mechanotherapy in one quadrant and the combined use of peizocision and photobiomodulation in the opposite quadrant, it was observed that the experimental side had the highest rate of tooth movement compared to all the groups in the study. The highest rate was observed at T1 in the quadrant subjected to the combination of photobiomodulation and piezocision. A difference of 0.19 was noted on the experimental side, however, this was not found to be statistically or clinically significant. Similar results were noted in a study conducted by Abdelhameed and Refal in 2018, wherein a combination of low-level laser therapy and microosteoperforation was used to enhance the tooth movement. A significant increase in orthodontic tooth movement was seen, with a 1.8-fold increase in the side subjected to the combination technique. This may be due to the effect of the laser therapy on the RANK/RANKL ligand and the RANK/OPG system which induces the process of osteoclastogenesis and the effect of microosteoperforation on the regional bone turnover. Similar findings were demonstrated in a study by Moradinejadin 2022, wherein piezocision and low-level laser therapy were assessed individually and in combination. A greater rate of tooth

movement was seen the combination group when compared to the groups which were subjected to an isolated laser therapy and an isolated piezocision therapy.

The findings of the study indicate that low-level laser therapy and piezocision have a synergistic effect on each other when compared to piezocision and laser therapy as individual techniques. Several studies indicate that low-level laser therapy may cause a decreased pain perception in patients, whereas several patients complain of discomfort after the piezocision technique. A combination of these techniques may be effective, but further research is needed.

The weakest influence in accelerating orthodontic tooth movement was found in the laser group, whereas the greatest effect was seen in the group wherein the piezocision and laser therapy were used synergistically. These results are in agreement with the results demonstrated by Moradinejad et al in 2022.

7. CONCLUSIONS

The following conclusions can be drawn from the study:

1. It was observed that the photobiomodulation therapy and piezocision had an enhanced effect on the rate of orthodontic tooth movement, however, these differences were not statistically significant.

2. The results of the study also demonstrated a synergistic effect of photobiomodulation therapy and piezocision on the rate of tooth movement with the highest rate of tooth movement seen in the group which combined the photobiomodulation and piezocision technique.

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